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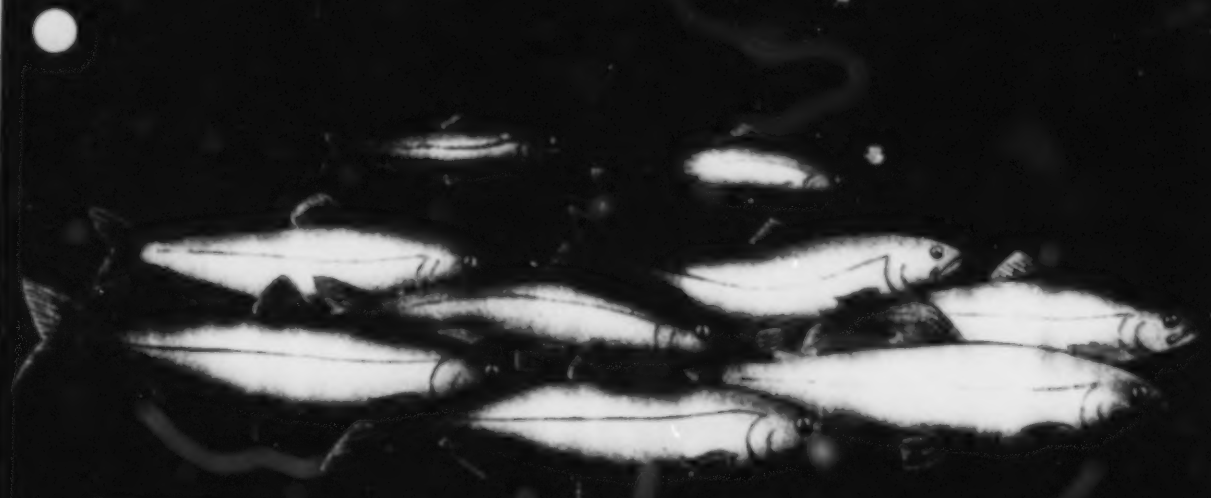

ENVIRONMENTAL MONITORING PROGRAM FOR MARINE FISH FARMS

BC MINISTRY OF ENVIRONMENT

MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

ENVIRONMENTAL MONITORING PROGRAM FOR MARINE FISH FARMS

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1. GENERAL INFORMATION

1.1 INTRODUCTION

The marine finfish aquaculture sector has expanded rapidly in British Columbia during the past few years. Associated with this growth has been a need to identify and manage the impacts that salmon farms may have on the marine environment and its resources. The Ministry of Environment, together with other provincial and federal regulatory and management agencies and the salmon farming industry, has been pursuing a number of initiatives to respond to this challenge. These activities include research on specific issues such as the impacts of salmon farming on benthic organisms and phytoplankton, water quality monitoring adjacent to selected farms, and the development of a waste management regulation and environmental guidelines. These, along with a variety of other activities, are assisting the Ministry in evaluating the impacts of finfish farming on the marine environment and in determining the type of regulation required to ensure that salmon farming does not unduly impact other marine resources and activities.

Much of the direction for this work is based on the recommendations of "An Inquiry into Finfish Aquaculture in British Columbia" chaired by David Gillespie in late 1986. Gillespie identified a number of shortcomings in the manner in which the industry was being managed. In particular, he noted that environmental monitoring represented a major deficiency in the regulation of finfish aquaculture and recommended that a mandatory environmental monitoring and data gathering system be established for each site and surrounding area. Since Cabinet adoption of Gillespie's recommendations in early 1987, the Ministry of Environment has been working with other government agencies and the salmon industry to develop such a program. This manual represents the results of this work.

Marine netcage fish farming in British Columbia involves the introduction of large quantities of fish feed into ocean water. Most of this feed is consumed by the fish and is utilized for growth and other metabolic processes, however, a significant percentage of the ingested food is subsequently excreted as fish waste products. These materials, in combination with unconsumed feed which passes through the netcages, constitute a potentially significant input of oxygen-consuming and enriching waste to the marine environment and has given rise to concerns over their impacts. In addition, fish farming involves the use of materials such as therapeutants, pesticides, and antifoulants, and requires the disposal of dead fish and domestic sewage. These activities also have potential environmental consequences.

In an effort to address these concerns, the Ministry of Environment has developed an Environmental Monitoring Program to provide data and information for impact assessment. The information requirements include data regarding the type and quantities of materials which are used as a regular part of netcage fish farming. This information will enable the Ministry of Environment to estimate waste loading to the environment. Data on currents and temperature/salinity profiles are basic oceanographic parameters essential for assessing the movement of water masses and estimating assimilative capacity. Monitoring of dissolved oxygen and ammonia is important both to the farmer and to the surrounding environment. Variations from normal values caused by farm activities will stress the penned fish and may also impact adjacent marine resources. Nitrogen excreted by the penned fish and released from decaying waste feed and faeces is important due to the potential for stimulating phytoplankton growth. Finally, dive surveys are required to determine the extent and impact of waste feed and faeces which can accumulate under netcages. Excessive build up of organic matter can be harmful to the penned fish and may result in degradation of the aquatic habitat.

The monitoring program is designed to complement more detailed research studies supported by the Ministry of Environment and the Ministry of Agriculture and Fisheries. Information from the monitoring program and the research studies will guide future decisions regarding government regulations and environmental management policies, as well as providing a useful tool to enhance farm husbandry practices. After an initial investigative period of approximately three years, the monitoring requirements will be reassessed. In the interim, the Ministry of Environment will compile and disseminate annual summaries of the monitoring program results.

This manual provides the farmer (or the farm consultant) with all the information needed to determine monitoring requirements, methodologies, and format for reporting data. If clarification is required, please contact your Regional Waste Management office. Appendix 3 lists the addresses and telephone numbers of these offices.

All netcage fish farms located in tidal waters must comply with one of three monitoring schedules. The monitoring schedule applicable to your farm is determined by your annual feed usage; how to determine which schedule applies to your farm is explained in Section 1.3 of the manual. In special circumstances, amendments to these schedules may be made by the Regional Waste Manager. Should it become apparent that certain monitoring requirements cannot be met, or that a certain sampling methodology is inappropriate, please contact the Regional Waste Manager for resolution.

The manual also includes an appendix which provides further details on sampling methods, analytical techniques, and instrumentation. The appendix also contains samples of the data entry forms required. Additional data entry forms should be obtained from Regional Waste Management offices as required.
For information on optimum values for the various parameters being measured, the reader is referred to Biophysical Criteria for Siting

Salmon Farms in British Columbia (Caine, Truscott, Reid, & Ricker, 1987). This publication is available from the Aquaculture Association of B.C.

References to specific products and/or company names are intended only as an aid to the farmer and should not be interpreted as exhaustive listings of all available products and services. The Ministry of Environment does not endorse any specific product line or company.

1.2 COMPLIANCE

Compliance with the Environmental Monitoring Program is mandatory for all marine netcage fish farms in British Columbia. Compliance is a requirement of the Waste Management Act and may be a condition of your Crown lease or licence. Submitting false or misleading information is an offence under the Waste Management Act and could result in a fine and/or loss of tenure.

Farm operators are required to sign a declaration certifying the accuracy of information submitted. In addition, monitoring efforts will be subject to occasional quality assurance inspections by Ministry of Environment staff.

It is recommended that a professional marine biologist or other qualified specialist be retained to undertake or supervise the field sampling portion of this program. If such an individual is not available on the farm staff, it may be advisable to employ a qualified consultant as needed. This is particularly true with respect to the current measurement and diver survey requirements (where applicable). This will minimize equipment needs for the farm operator and will help to ensure high quality results.

1.3 FEED USAGE CATEGORY

It is expected that the potential for water quality impacts will be directly related to the amount of feed used on the farm. The Environmental Monitoring Program has therefore been designed to require more extensive monitoring for farms using larger quantities of feed.

Three categories of monitoring have been established based on annual feed usage. As each category has different monitoring requirements, the first step is to identify the correct Monitoring Schedule for your farm. Each Crown lease or licence of occupation is considered a separate farm and must be reported independently.

Estimate the total dry weight of fish feed to be used in the ensuing calendar year on the farm site. Although this feed will normally be in the form of wet feed (or silage), moist feed, or dry feed, total feed should be calculated in terms of dry weight only. Note that dry feed is not equivalent to dry weight. Dry weight of feed can usually be determined by referring to the feed manufacturer's product specifications. These specifications should include the moisture content of the feed and this content can then be subtracted from the total weight of the feed to yield total dry weight. If moisture content specifications are not provided by the feed supplier or manufacturer, it is the responsibility of the farmer to make this determination. Percent moisture is defined as the percent loss in weight of feed when dried to a constant weight at a temperature of 105 degrees Celsius. Refer to the appendix for details of this procedure.

For example, if annual feed requirements for a salmon farm are:

- 500 tonnes dry feed with 10% moisture content
- 80 tonnes moist feed with 35% moisture content
- and 50 tonnes wet feed with 70% moisture content

then the total feed usage in terms of dry weight will be:

= (500 - 10%) + (80 - 35%) + (50 - 70%)
= (500 - 50) + (80 - 28) + (50 - 35)
= 450 + 52 + 15
= 517 tonnes dry weight

If the total dry weight of feed is less than 120 tonnes, use Monitoring Schedule A which requires only a minimum of record keeping information. If the total dry weight of feed is between 120 tonnes and 630 tonnes inclusive, use Monitoring Schedule B which has additional requirements for basic oceanographic data and a diver survey of bottom sediments. Farms using in excess of 630 dry weight tonnes of feed annually are referred to Monitoring Schedule C and are subject to more intensive monitoring which includes a nutrient (nitrogen) monitoring component. Table 1 shows the Monitoring Schedules associated with each feed use category. Calculate your total feed usage and indicate your correct Monitoring Schedule in Section H of Data Form I (Appendix).

TABLE 1. Monitoring Schedules

Dry Weight of Feed (tonnes)	Monitoring Schedules
< 120	A
120 - 630	B
> 630	C

After estimating the annual feed usage and establishing the correct Monitoring Schedule of the fish farm (Table 1), proceed to the appropriate section of this manual for detailed instructions on monitoring requirements. Table 2 shows a summary of the monitoring requirements and indicates Ministry of Environment

TABLE 2. Monitoring and Permitting Requirements

Schedule	Monitoring Requirements	Permits For Fish Feed and Faeces*
A	- materials accounting, fish production, and waste handling.	Exempt
B	- materials accounting, fish production, and waste handling. - monthly temperature/salinity profiles for a period of one year. - one time only measurement of current speed/direction during a one month period. - monthly temperature/D.O. profiles during summer months only. - annual qualitative diver survey of bottom sediments and benthic community.	Exempt
C	- materials accounting, fish production, and waste handling. - monthly temperature/salinity/D.O. profiles. D.O. profile to be repeated in late afternoon. - one time only measurement of current speed/direction during a one month period. - monthly ammonia/nitrite/nitrate profiles. - annual qualitative diver survey of bottom sediments and benthic community.	Permit Required

*These exemptions refer to fish feed and faeces. Discharge of less than 2.5 m^3/day of domestic sewage also is exempt from

permitting requirements, under certain conditions, regardless of feed usage. Disposal of wastes to landfill requires a permit. For details regarding these conditions and requirements, refer to Environmental Guidelines for Marine Fish Farms and Ancillary Operations, Ministry of Environment.

permitting requirements which may apply. Please note that farms which use more than 630 tonnes of feed (dry weight) per year (Monitoring Schedule C) will be required to apply for a Waste Management Permit or Approval for feed and faeces waste. The monitoring requirements specified in this manual for farms in the largest feed use category (Monitoring Schedule C) represent a basic requirement; the Regional Waste Manager may specify additional monitoring requirements when issuing the permit. Please refer to the Environmental Guidelines For Marine Fish Farms and Ancillary Operations, Ministry of Environment, for a detailed explanation of these permitting requirements.

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MONITORING

SCHEDULE

A

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2. MONITORING SCHEDULE A

2.1 SUMMARY

Farms using less than 120 tonnes dry weight of feed per year are required to report information specified in Schedule A. This schedule requires information on: material usage such as feed, therapeutants, and antifoulants in addition to data on mortalities, biomass and waste handling practices. These requirements are common to all three monitoring schedules.

2.2 MATERIALS ACCOUNTING, FISH PRODUCTION, AND WASTE HANDLING

Information must be entered quarterly on Data Form I (Appendix 4) and submitted to the appropriate Regional Waste Management office (Appendix 3) by no later than 30 days after each quarter.

Data Form I is divided into sections as follows:

Section A - General Information

KEY NUMBER - Office use only. Leave this space blank.

QUARTER - Indicate which quarter the data form refers to (i.e. Jan-Mar, Apr-Jun, Jul-Sep, or Oct-Dec).

YEAR - Indicate the calendar year to which the data form refers.

COMPANY NAME - Fill in the name of the company or individual who owns/operates the fish farm. If the farm is operating on Crown land under a lease/licence, then COMPANY NAME should correspond to the issuee of the Lands tenure document.

LANDS FILE NUMBER - If the fish farm is operating on a Crown lease or licence, provide the Lands Branch file number.

SITE LOCATION - Provide a very brief description of where the fish farm is located; i.e., Saanich Inlet near Coal Point.

LATITUDE AND LONGITUDE - Provide latitude and longitude of the farm site to the nearest tenth minute. This information can be extracted from a Canadian Hydrographic Chart.

CHART DATUM - Report the chart datum at the approximate centre of the netcage array. Chart datum is the depth at the lowest normal tide. It can be calculated by subtracting the tide height at any given time (as determined from the Canadian Tide and Current Tables) from the actual measured depth at that time (as determined by a measured sounding line). Depth should be reported to the nearest 0.5 metres.

PLANKTON WATCH - Indicate whether or not the farm submitted information to the Plankton Watch Program during the quarter.

NET DEPTH - Record the depth in metres of the deepest netcage and the average depth of all the netcages in use on the farm site. Calculate the average depth of all the netcages by adding the depth of all netcages and dividing by the number of netcages.

NAME - Provide the name of the submitter of the data form.

TELEPHONE NUMBER - Provide the telephone (or radiotelephone) number at which the submitter of the data form can be reached.

WASTE PERMIT NUMBERS - If Waste Permits have been issued by the Waste Management Branch for any aspect of the farm operation, please record the permit numbers in this space.

Section B - Feed Type and Quantity

List all types and amounts of fish feed actually used on the farm during the quarter and indicate the corresponding moisture content for each type.

TYPE - List separately each feed type that is used. For example, if silage is used, then the source of the silage should be described (i.e., herring silage). If a commercial feed is used, specify the product name (i.e., Moore-Clark Chinook Mash or Trend Developer) or provide a generic description of the feed type.

AMOUNT - List corresponding total amount used during the quarter for each feed type. Amounts are to be expressed in kilograms.

PERCENT MOISTURE - Record percent moisture for each feed listed. Feed moisture content can usually be obtained from the manufacturer's specifications. If the moisture content is not provided by the supplier or manufacturer, it is up to the farmer to have this determination made. Percent moisture is defined as the percent loss in weight of feed when dried to a constant weight at 105 degrees Celsius. Refer to Appendix 1.2 for details on procedures for percent moisture determination.

DRY WEIGHT - Calculate the dry weight for each feed listed by subtracting the moisture content from the actual amount used during the quarter. Provide total dry weight as indicated on the data form. Refer to Section 1.3 for an example of this calculation.

Section C - Other Materials

This section should list all materials (other than those which are a normal constituent of the feed type) that are directly or indirectly released to the water during the quarter. This list should include, but not be confined to: therapeutants, pigments, hormones, pesticides, anaesthetics, antifoulants applied to nets or other surfaces, disinfectants, and cleansers. Materials administered directly to fish by injection are excluded.

NAME - List the product names for all materials used during the quarter.

TYPE - Describe the nature of the material; i.e., pesticide, antifoulant, etc.

AMOUNT - Record the corresponding amount of material used during the quarter. Do not forget to include appropriate units of measure.

APPLICATION - Briefly describe how the material was applied and disposed of. For example, was it put directly into the water as for sea lice? Was it added to the feed as a

supplement? Was it painted onto nets or floats as for an antifoulant? Or, was it released after use as with baths or dips?

Section D - Production

BIOMASS - Estimate the total weight (or "biomass") of all live fish on the farm site at the end of the quarter. Combine all species, size classes, and age classes for this total.

WEIGHT OF MORTALITIES - Estimate the total weight of all fish that died on the farm site during the quarter. Combine all species, size classes, and age classes for this total.

Section E - Dead Fish Disposal

Indicate the method used for disposal of dead fish originating from the farm site. If a collection/disposal service is employed for off site disposal, please indicate the name of the contractor. If off site disposal is carried out by the farm staff, indicate the location and method of disposal.

Section F - Sewage Disposal

Record the average number of people working on the farm site during the quarter. Indicate the method used for disposal of human sewage on the farm site i.e., chemical toilet, incinerator toilet, compost toilet etc. If a septic tank is used, please indicate if it discharges to a shore-based tile field, or discharges to marine waters. If discharged to marine waters, specify the depth of discharge and volume of the septic tank.

Section G - Bleeding

Indicate if fish are bled <u>on the farm site</u> prior to processing or shipment to a processing plant. If fish are bled on the farm site, indicate what method is used for

disposal of the effluent. If a collection/disposal service is employed for off site disposal, please indicate the name of the contractor.

Section H - Projected Annual Feed Usage

This section assists the farmer in determining the correct Monitoring Schedule to be implemented in the coming calendar year. Farms are required to comply with the monitoring requirements based on their predicted feed usage.

To complete this section, estimate and record feed requirements for each feed type for the ensuing calendar year. Beside each feed type, record the moisture content of the feed. Subtract the moisture content from each feed type to convert to dry weight. Finally, sum all dry weights and refer to Table 1 (page 7) to arrive at the correct Monitoring Schedule for the following year. This projection is required only in the third quarter reports.

Completion of Sections A through H fulfill all of the basic Schedule A requirements. Additional information may be required by the Regional Waste Manager in response to site specific environmental circumstances. The fish farmer is encouraged to submit any further data or observations felt to be relevant to the interpretation of information supplied as part of the Environmental Monitoring Program (for example, details of the occurrence of fish kills due to specific diseases or plankton blooms).

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MONITORING

SCHEDULE

B

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3. MONITORING SCHEDULE B

3.1 SUMMARY

Farms using between 120 tonnes and 630 tonnes inclusive of dry weight feed per year are required to report the information specified in Schedule B. This information includes the following:

- materials accounting, fish production, and waste handling (common to all three of the monitoring schedules).
- monthly temperature/salinity profiles for a period of one year.
- one time only measurement of current speed/direction during a one month period.
- monthly temperature/D.O. profiles during summer months only.
- annual qualitative diver survey of bottom sediments and benthic community.

3.2 MATERIALS ACCOUNTING, FISH PRODUCTION, AND WASTE HANDLING

Information must be entered quarterly on Data Form I (Appendix 4) and submitted to the appropriate Regional Waste Management office (Appendix 3) by no later than 30 days after each quarter.

Data Form I is divided into sections as follows:

Section A - General Information

KEY NUMBER - Office use only. Leave this space blank.

QUARTER - Indicate which quarter the data form refers to (i.e. Jan-Mar, Apr-Jun, Jul-Sep, or Oct-Dec).

YEAR - Indicate the calendar year to which the data form refers.

COMPANY NAME - Fill in the name of the company or individual who owns/operates the fish farm. If the farm is operating on Crown land under a lease/licence, then COMPANY NAME should correspond to the issuee of the Lands tenure document.

LANDS FILE NUMBER - If the fish farm is operating on a Crown lease or licence, provide the Lands Branch file number.

SITE LOCATION - Provide a very brief description of where the fish farm is located; i.e., Saanich Inlet near Coal Point.

LATITUDE AND LONGITUDE - Provide latitude and longitude of the farm site to the nearest tenth minute. This information can be extracted from a Canadian Hydrographic Chart.

CHART DATUM - Report the chart datum at the approximate centre of the netcage array. Chart datum is the depth at the lowest normal tide. It can be calculated by subtracting the tide height at any given time (as determined from the Canadian Tide and Current Tables) from the actual measured depth at that time (as determined by a measured sounding line). Depth should be reported to the nearest 0.5 metres.

PLANKTON WATCH - Indicate whether or not the farm submitted information to the Plankton Watch Program during the quarter.

NET DEPTH - Record the depth in metres of the deepest netcage and the average depth of all the netcages in use on the farm site. Calculate the average depth of all the netcages by adding the depth of all netcages and dividing by the number of netcages.

NAME - Provide the name of the submitter of the data form.

TELEPHONE NUMBER - Provide the telephone (or radiotelephone) number at which the submitter of the data form can be reached.

WASTE PERMIT NUMBERS - If Waste Permits have been issued by the Waste Management Branch for any aspect of the farm operation, please record the permit numbers in this space.

Section B - Feed Type and Quantity

List all types and amounts of fish feed actually used on the farm during the quarter and indicate the corresponding moisture content for each type.

TYPE - List separately each feed type that is used. For example, if silage is used, then the source of the silage

should be described (i.e., herring silage). If a commercial feed is used, specify the product name (i.e., Moore-Clark Chinook Mash or Trend Developer) or provide a generic description of the feed type.

AMOUNT - List corresponding total amount used during the quarter for each feed type. Amounts are to be expressed in kilograms.

PERCENT MOISTURE - Record percent moisture for each feed listed. Feed moisture content can usually be obtained from the manufacturer's specifications. If the moisture content is not provided by the supplier or manufacturer, it is up to the farmer to have this determination made. Percent moisture is defined as the percent loss in weight of feed when dried to a constant weight at 105 degrees Celsius. Refer to Appendix 1.2 for details on procedures for percent moisture determination.

DRY WEIGHT - Calculate the dry weight for each feed listed by subtracting the moisture content from the actual amount used during the quarter. Provide total dry weight as indicated on the data form. Refer to section 1.3 for an example of this calculation.

Section C - Other Materials

This section should list all materials (other than those which are a normal constituent of the feed type) that are directly or indirectly released to the water during the quarter. This list should include, but not be confined to: therapeutants, pigments, hormones, pesticides, anaesthetics, antifoulants applied to nets or other surfaces, disinfectants, and cleansers. Materials administered directly to fish by injection are excluded.

NAME - List the product names for all materials used during the quarter.

TYPE - Describe the nature of the material; i.e., pesticide, antifoulant, etc.

AMOUNT - Record the corresponding amount of material used during the quarter. Do not forget to include appropriate units of measure.

APPLICATION - Briefly describe how the material was applied and disposed of. For example, was it put directly into the water as for sea lice? Was it added to the feed as a supplement? Was it painted onto nets or floats as for an antifoulant? Or, was it released after use as with baths or dips?

Section D - Production

BIOMASS - Estimate the total weight (or "biomass") of all live fish on the farm site at the end of the quarter. Combine all species, size classes, and age classes for this total.

WEIGHT OF MORTALITIES - Estimate the total weight of all fish that died on the farm site during the quarter. Combine all species, size classes, and age classes for this total.

Section E - Dead Fish Disposal

Indicate the method used for disposal of dead fish originating from the farm site. If a collection/disposal service is employed for off site disposal, please indicate the name of the contractor. If off site disposal is carried out by the farm staff, indicate the location and method of disposal.

Section F - Sewage Disposal

Record the average number of people working on the farm site during the quarter. Indicate the method used for disposal of human sewage on the farm site i.e., chemical toilet, incinerator toilet, compost toilet etc. If a septic tank is used, please indicate if it discharges to a shore-

based tile field, or discharges to marine waters. If discharged to marine waters, specify the depth of discharge and volume of the septic tank.

Section G - Bleeding

Indicate if fish are bled <u>on the farm site</u> prior to processing or shipment to a processing plant. If fish are bled on the farm site, indicate what method is used for disposal of the effluent. If a collection/disposal service is employed for off site disposal, please indicate the name of the contractor.

Section H - Projected Annual Feed Usage

This section assists the farmer in determining the correct Monitoring Schedule to be implemented in the coming calendar year. Farms are required to comply with the monitoring requirements based on their <u>predicted</u> feed usage.

To complete this section, estimate and record feed requirements for each feed type for the ensuing calendar year. Beside each feed type, record the moisture content of the feed. Subtract the moisture content from each feed type to convert to dry weight. Finally, sum all dry weights and refer to Table 1 (page 7) to arrive at the correct Monitoring Schedule for the following year. This projection is required only in the third quarter reports.

3.3 <u>MONTHLY TEMPERATURE AND SALINITY PROFILES FOR ONE YEAR</u>

All fish farms which fall into Monitoring Schedule B must provide monthly temperature and salinity profiles for a period of at least one year. Data must be entered on Data Form II (Appendix 4) and submitted to the Regional Waste Management office at the conclusion of the first year of monitoring. Adequate space has been provided on the data form to accommodate all twelve of the required monthly profiles. In some cases, the temperature/salinity

monitoring requirements may already have been met as a result of previous studies. If so, these data may be submitted on Data Form II, subject to the approval of the Regional Waste Manager. This monitoring must be initiated within three months of a farm becoming subject to Schedule B.

Temperature and salinity "profiles" refer to measurement of these parameters at several prescribed depths through the water column. Sampling can be conducted anywhere around the netcage array but should not be done within a netcage. Although sampling is required on a monthly basis, selection of the specific day of the month on which sampling will occur is left to the discretion of the farm operator. Once a specific day of the month has been selected, subsequent sampling should be carried out on approximately the same day of each successive month. After twelve monthly profiles have been completed and the results submitted, no further temperature/salinity profiles are required.

Note the overlap between these monitoring requirements and those specified in Section 3.5. For the sake of efficiency, the temperature/salinity profiles can be measured at the same time as the summer temperature/oxygen profiles.

Data Form II has the following format:

DATE - Provide date that measurements were taken. Dates throughout the year should occur at one month intervals.

TIME - Record the time that sampling began. Please use local time and a 24 hour clock (i.e., 1800 rather than 6:00 PM).

DEPTH - Determine and record the water depth in metres at the sample location during the time of sampling. A weighted, measured line is the simplest means of obtaining this information.

TIDE STATUS - Indicate if the tidal current is ebbing or flooding or if it is slack water during the sampling time.

TEMPERATURE - Water temperature must be measured at the following depths: 1 metre, 5 metres, 10 metres, 20 metres, 30

metres (if depth permits) and 1 metre above the bottom ("BOTTOM-1"). Temperatures are to be reported in degrees Celsius and to an accuracy of 0.5 degrees.

SALINITY - Salinity of the water must be measured at the same depths as temperature: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits) and 1 metre above the bottom. Salinity is to be recorded in parts per thousand and should be recorded to an accuracy of 0.5 ppt. Refer to Section 1.7 of Appendix 1 for details regarding methodology and equipment.

3.4 CURRENT SPEED AND DIRECTION

All farms in Monitoring Schedule B must characterize the current regime at the farm site for a period of one month only. Current speed and direction are to be recorded at a minimum frequency of once per hour during the one month (30 days) period, so an automatic recording device is a necessity. These devices can be rented or purchased, but use of a qualified consultant is the simplest alternative and is recommended. In some cases, the current monitoring requirements already may have been met as a result of previous studies. If so, these data may be submitted subject to the approval of the Regional Waste Manager without further monitoring. Report data on Data Form III (Appendix 4). This monitoring requirement must be met within two years of a farm becoming subject to Schedule B.

The precise timing of the current assessment is left to the discretion of the farmer, but current measurements must be made during a month of average tidal fluctuations. Measurements of current speed and direction must be made at intervals of one hour or less until a full 30 days have elapsed.

The current measuring instrument should be located away from the attenuation effects of the netcages or other farm structures. In other words, it should not be located immediately adjacent to the netcages and not in line with prevailing currents such that

the current meter is measuring currents that have been "dampened" by the nets themselves. In most cases, the current meter should be moored about 30 metres from the offshore side of the netcages. The current meter should be suspended from a surface float at a depth of 15 metres. Record current direction in degrees (relative to true north) and current speed in cm/sec. Either vector averaging or instantaneous type meters may be used.

Upon completion, compiled data is to be forwarded to the Regional Waste Management office. Raw data indicating current speed and direction for each sampling interval should be provided in an ASKI computer format (diskette or mag tape) and must be accompanied by adequate format documentation. Submitters should also include a summary of the data in the form of a tabular frequency distribution of both current speed and current direction as specified on Data Form III. Refer to Section 1.9 of the Appendix for further details on methodology.

Data Form III has the following format:

START DATE - Record the date that the current meter commenced current monitoring.

START TIME - Record the time that the current meter commenced current monitoring. Use local time and a 24 hour clock.

END DATE - Record the date that current monitoring was terminated.

END TIME - Record the time that current monitoring was terminated. Use local time and a 24 hour clock.

SAMPLE INTERVAL - Report the sample interval in minutes between consecutive measurements made by the meter. Sample interval cannot be greater than sixty minutes.

INSTRUMENT - Provide details as to the make and model of current meter employed to conduct the monitoring.

DATA - Indicate whether current meter averages current speed and direction over the selected interval, or if it provides instantaneous measurements.

NAME - Provide the name of the person or consulting company that is performing the current monitoring.

3.5 MONTHLY TEMPERATURE AND DISSOLVED OXYGEN PROFILES

All Schedule B farms must undertake monitoring of temperature and dissolved oxygen values during the summer months on an annual basis. Profiles are to be taken a minimum of once a month during the period of April to September inclusive. Data must be entered on Data Form IV (Appendix 4) and submitted to the Regional Waste Management office with other third quarter submissions each year (i.e. by not later than November 1 each year).

Although sampling is required on a monthly basis, selection of the specific day of the month on which sampling will occur is left to the discretion of the farm operator. Once a specific day of the week has been selected, every effort should be made to ensure that sampling is carried out at one month intervals thereafter. Sampling is to be conducted in the early morning (within two hours of sunrise) so as to sample during the daily oxygen minimum.

Two sites must be sampled on each sample date. One sample site should be located on the upstream side of the netcage array and the other should be located on the downstream side of the array. Determination of "upstream" and "downstream" should be based on actual observation of position of nets and water movement and not on assumed or predicted tidal currents. Refer to Appendix 1 for details regarding methodology and equipment.

Data Form IV has the following format:

DATE - Provide date that measurements were taken. Dates throughout the sample period should occur at one month intervals.

TIME - Record the time that sampling began. Please use local time and a 24 hour clock. Time should be no later than two hours after sunrise.

TIDE STATUS - Indicate if the tidal current is ebbing or flooding or if it is slack during the sample time.

DEPTH - Determine and record the water depth at both sample sites during the sample time.

SECCHI DEPTH - Determine and record the Secchi depth at both sample sites in metres using a standard Secchi disc.

TEMPERATURE - Water temperature must be measured at the following depths: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits), and 1 metre above the bottom ("BOTTOM-1"). Temperatures are to be recorded in degrees Celsius and to an accuracy of 0.5 degrees.

DISSOLVED OXYGEN - Dissolved oxygen of the water must be measured at the same depths as temperature: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits) and 1 metre above the bottom. Concentrations are to be reported as milligrams per litre and to an accuracy of 0.2 mg/l.

3.6 SEDIMENT ACCUMULATION AND BENTHIC SURVEY

All Schedule B farms are required to conduct an annual underwater survey to provide an assessment of the extent of farm derived organic sedimentation and the degree of impact on the benthic community. The initial underwater survey must be completed within two years of a farm becoming subject to Schedule B, and annually thereafter. The survey should be performed during a period of good visibility and should be repeated each successive year at approximately the same time. Results of the survey must be compiled in a typed report and submitted to the Regional Waste Management office along with other quarterly submissions.

Diving will be necessary to make the required assessment, but in the interests of diver safety, the survey need not exceed a maximum depth of 30 metres. Diving around netcages can be hazardous and only qualified divers working in compliance with Workers' Compensation Board Regulations should be employed. Sophisticated techniques are not required for this survey, however

it is recommended that the diving be conducted or supervised by a qualified professional biologist to ensure that the assessment is reliable.

Farm operators may wish to employ a video equipped underwater "remotely operated vehicle" (ROV) as a possible alternative to the use of divers for some aspects of the survey. These devices can be rented or purchased, however their utility for such an application is not well established. Operators considering use of an ROV as part of their survey should consult with the Regional Waste Manager if deviations from the prescribed methodology are anticipated.

The following information should be reported (no data form provided):

Section A - Site description

Provide a sketch map drawn to scale showing the following:

i. The entire farm site with netcages, walkways, buildings, etc.
ii. A directional arrow indicating "north."
iii. Indicate 10 metre (or less) depth contours for the farm site.
iv. Show approximate areas of silt, sand, gravel, or rock substrate within the lease site.
v. Indicate presence or absence of sediment accumulations on the sketch map. If sediment accumulations are present, provide an estimate of sediment depth. This can be obtained by a diver probing the sediment with a ruler.
vi. Indicate the distribution of bacterial "mats" (i.e. Beggiatoa sp.), if present.

Section B - Benthic fauna and flora survey

The benthic survey requires that the surveyor produce a brief assessment which describes qualitatively the major

organisms and marine plants of the benthic community. A competent diver-biologist knowledgeable of marine benthic invertebrate and macrophyte taxa should conduct the assessment.

The survey should characterize and compare the following three habitats:

i. The benthic community directly impacted by farm deposition.

ii. The benthic community adjacent to the deposition area within the lease site.

iii. A control area beyond the influence of the farm. Compare areas of similar substrate type, depth, and exposure to currents and wave action.

If any fish were encountered during the survey, their species and relative abundances also should be noted in the survey report.

Completion of Sections 3.1 through 3.6 fulfill all of the basic Schedule B monitoring requirements. Additional information may be required by the Regional Waste Manager in response to site specific environmental circumstances. The fish farm manager is encouraged to submit any further data or observations felt to be relevant to the interpretation of information supplied as part of the Environmental Monitoring Program (for example, details of the occurrence of fish kills due to specific diseases or plankton blooms).

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MONITORING

SCHEDULE

C

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4. MONITORING SCHEDULE C

4.1 SUMMARY

Farms using in excess of 630 tonnes of dry weight feed per year are required to report the information specified in Schedule C. This information includes the following:

- materials accounting, fish production, and waste handling (common to all three monitoring schedules).
- monthly temperature/salinity/D.O. profiles. D.O. profile to be determined in early morning and late afternoon on sample day.
- one time only measurement of current speed/direction during a one month period.
- monthly ammonia/nitrite/nitrate profiles.
- annual quantitative diver survey of bottom sediments and benthic community.

4.2 MATERIALS ACCOUNTING, FISH PRODUCTION, AND WASTE HANDLING

Information must be entered quarterly on Data Form I (Appendix 4) and submitted to the appropriate Regional Waste Management office (Appendix 3) by no later than 30 days after each quarter.

Data Form I is divided into sections as follows:

Section A - General Information

KEY NUMBER - Office use only. Leave this space blank.

QUARTER - Indicate which quarter the data form refers to (i.e. Jan-Mar, Apr-Jun, Jul-Sep, or Oct-Dec).

YEAR - Indicate the calendar year to which the data form refers.

COMPANY NAME - Fill in the name of the company or individual who owns/operates the fish farm. If the farm is operating on Crown land under a lease/licence, then COMPANY NAME should correspond to the issuee of the Lands tenure document.

LANDS FILE NUMBER - If the fish farm is operating on a Crown lease or licence, provide the Lands Branch file number.

SITE LOCATION - Provide a very brief description of where the fish farm is located; i.e., Saanich Inlet near Coal Point.

LATITUDE AND LONGITUDE - Provide latitude and longitude of the farm site to the nearest tenth minute. This information can be extracted from a Canadian Hydrographic Chart.

CHART DATUM - Report the chart datum at the approximate centre of the netcage array. Chart datum is the depth at the lowest normal tide. It can be calculated by subtracting the tide height at any given time (as determined from the Canadian Tide and Current Tables) from the actual measured depth at that time (as determined by a measured sounding line). Depth should be reported to the nearest 0.5 metres.

PLANKTON WATCH - Indicate whether or not the farm submitted information to the Plankton Watch Program during the quarter.

NET DEPTH - Record the depth in metres of the deepest netcage and the average depth of all the netcages in use on the farm site. Calculate the average depth of all the netcages by adding the depth of all netcages and dividing by the number of netcages.

NAME - Provide the name of the submitter of the data form.

TELEPHONE NUMBER - Provide the telephone (or radiotelephone) number at which the submitter of the data form can be reached.

WASTE PERMIT NUMBERS - If Waste Permits have been issued by the Waste Management Branch for any aspect of the farm operation, please record the permit numbers in this space.

Section B - Feed Type and Quantity

List all types and amounts of fish feed actually used on the farm during the quarter and indicate the corresponding moisture content for each type.

TYPE - List separately each feed type that is used. For example, if silage is used, then the source of the silage

should be described (i.e., herring silage). If a commercial feed is used, specify the product name (i.e., Moore-Clark Chinook Mash or Trend Developer) or provide a generic description of the feed type.

AMOUNT - List corresponding total amount used during the quarter for each feed type. Amounts are to be expressed in kilograms.

PERCENT MOISTURE - Record percent moisture for each feed listed. Feed moisture content can usually be obtained from the manufacturer's specifications. If the moisture content is not provided by the supplier or manufacturer, it is up to the farmer to have this determination made. Percent moisture is defined as the percent loss in weight of feed when dried to a constant weight at 105 degrees Celsius. Refer to Appendix 1.2 for details on procedures for percent moisture determination.

DRY WEIGHT - Calculate the dry weight for each feed listed by subtracting the moisture content from the actual amount used during the quarter. Provide total dry weight as indicated on the data form. Refer to Section 1.3 for an example of this calculation.

Section C - Other Materials

This section should list all materials (other than those which are a normal constituent of the feed type) that are directly or indirectly released to the water during the quarter. This list should include, but not be confined to: therapeutants, pigments, hormones, pesticides, anaesthetics, antifoulants applied to nets or other surfaces, disinfectants, and cleansers. Materials administered directly to fish by injection are excluded.

NAME - List the product names for all materials used during the quarter.

TYPE - Describe the nature of the material; i.e., pesticide, antifoulant, etc.

AMOUNT - Record the corresponding amount of material used during the quarter. Do not forget to include appropriate units of measure.

APPLICATION - Briefly describe how the material was applied and disposed of. For example, was it put directly into the water as for sea lice? Was it added to the feed as a supplement? Was it painted onto nets or floats as for an antifoulant? Or, was it released after use as with baths or dips?

Section D - Production

BIOMASS - Estimate the total weight (or "biomass") of all live fish on the farm site at the end of the quarter. Combine all species, size classes, and age classes for this total.

WEIGHT OF MORTALITIES - Estimate the total weight of all fish that died on the farm site during the quarter. Combine all species, size classes, and age classes for this total.

Section E - Dead Fish Disposal

Indicate the method used for disposal of dead fish originating from the farm site. If a collection/disposal service is employed for off site disposal, please indicate the name of the contractor. If off site disposal is carried out by the farm staff, indicate the location and method of disposal.

Section F - Sewage Disposal

Record the average number of people working on the farm site during the quarter. Indicate the method used for disposal of human sewage on the farm site i.e., chemical toilet, incinerator toilet, compost toilet etc. If a septic tank is used, please indicate if it discharges to a shore-

based tile field, or discharges to marine waters. If discharged to marine waters, specify the depth of discharge and volume of the septic tank.

Section G - Bleeding

Indicate if fish are bled <u>on the farm site</u> prior to processing or shipment to a processing plant. If fish are bled on the farm site, indicate what method is used for disposal of the effluent. If a collection/disposal service is employed for off site disposal, please indicate the name of the contractor.

Section H - Projected Annual Feed Usage

This section assists the farmer in determining the correct Monitoring Schedule to be implemented in the coming calendar year. Farms are required to comply with the monitoring requirements based on their <u>predicted</u> feed usage.

To complete this section, estimate and record feed requirements for each feed type for the ensuing calendar year. Beside each feed type, record the moisture content of the feed. Subtract the moisture content from each feed type to convert to dry weight. Finally, sum all dry weights and refer to Table 1 (page 7) to arrive at the correct Monitoring Schedule for the following year. This projection is required only in the third quarter reports.

4.3 <u>MONTHLY TEMPERATURE, SALINITY, AND DISSOLVED OXYGEN PROFILES</u>

All Schedule C farms must undertake regular monitoring of temperature, salinity, and dissolved oxygen. Profiles are to be taken once a month. Data must be entered on Data Form V (Appendix 4) and submitted along with other quarterly reports to the Regional Waste Management office by not later than 30 days after each quarter.

Temperature/salinity/D.O. "profiles" refer to measurements of these parameters at several prescribed depths through the water column. These profiles should be performed adjacent to netcages, not within the nets themselves.

Although sampling is required on a monthly basis, selection of the specific day of the month on which sampling will occur is left to the discretion of the farm operator. Once a specific day of the week has been selected, every effort should be made to ensure that sampling is carried out at one month intervals thereafter.

Profiles are to be taken at two distinct times on the day of sampling, and at two sites. The first set of profiles should be conducted in the early morning (within two hours of sunrise) so as to sample during the daily oxygen minimum. This set of profiles must include temperature, salinity, and dissolved oxygen measurements. One profile should be determined at a site located on the upstream side of the netcage array and the other should be located on the downstream side of the array. The second set of profiles should be conducted in the late afternoon, approximately 12 hours after completion of the morning profiles. This second set of profiles need only include dissolved oxygen measurements (temperature and salinity may be omitted). The afternoon D.O. profiles should be performed at an upstream site and a downstream site. Determination of "upstream" and "downstream" should be based on actual observation of position of nets and water movement and not on assumed or predicted tidal currents. Refer to Appendix 1 for details regarding methodology and equipment.

Data Form V has the following format:

QUARTER - Indicate which quarter the data form refers to (i.e. Jan-Mar, Apr-Jun, Jul-Sep, or Oct-Dec).

DATE - Provide date that measurements were taken for each monthly set of profiles. Enough space is provided to record the three monthly profiles required in each quarter.

TIME - Record the time that sampling began. Note that morning sampling should occur within two hours after sunrise and late afternoon sampling should occur approximately twelve hours later. Please use local time and a 24 hour clock (i.e. use 1800 rather than 6:00 PM).

TIDE STATUS - Indicate if the tidal current is ebbing or flooding or if it is slack during the sample time.

DEPTH - Determine and record the water depth in metres at the sample location during the time of sampling. A simple weighted, measured line is the simplest means of obtaining this information.

SECCHI DEPTH - Determine and record the Secchi depth at both sample sites in metres using a standard Secchi disc. Secchi depth need only be determined during the morning profiles.

TEMPERATURE - Water temperature must be measured at both sample sites at the following depths: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits), and 1 metre above the bottom ("BOTTOM-1"). Temperature need only be determined during the morning profiles. Temperatures are to be recorded in degrees Celsius and to an accuracy of 0.5 degrees.

SALINITY - Salinity should be measured at the upstream sample site only, but at the same depths as for temperature: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits), and 1 metre above the bottom. Salinity need only be determined during the morning profiles. Salinity is to be recorded in parts per thousand and should be determined to an accuracy of 0.5 ppt.

DISSOLVED OXYGEN - Dissolved oxygen of the water must be measured at both sample sites at the same depths as for temperature: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits), and 1 metre above the bottom ("BOTTOM-1"). Dissolved oxygen must be measured both during the morning profiling, and twelve hours later during the

afternoon profiling. Concentrations are to be expressed as milligrams per litre and to an accuracy of 0.2 mg/l.

4.4 MONTHLY AMMONIA AND NITRITE PLUS NITRATE PROFILES

All Schedule C farms must conduct regular monitoring of ammonia and nitrite plus nitrate concentrations at the farm site. Profiles are to be taken on the same day as for temperature/salinity/D.O. profiles i.e., once a month. Data must be entered on Data Form VI and submitted along with corresponding quarterly reports to the Regional Waste Management office by not later than 30 days after each quarter.

An ammonia and nitrite+nitrate profile is only required for one site and at one time during each monthly sampling session. Collection of samples should be timed to coincide with apparent slack water and should occur at a site near the centre of the netcage array.

Data Form VI has the following format:

QUARTER - Indicate which quarter the data form refers to (i.e. Jan-Mar, Apr-Jun, Jul-Sep, or Oct-Dec).

DATE - Provide date that measurements were taken for each monthly profile. Enough space is provided to record the three monthly profiles required in each quarter.

TIME - Record the time that sampling began. Note that time should correspond with slack water. Please use local time and a 24 hour clock.

DEPTH - Determine and record the water depth in metres at the sample location during the time of sampling.

AMMONIA - Determine and record the concentration of total ammonia nitrogen at the following depths: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres (if depth permits), and 1 metre above the bottom ("BOTTOM-1"). Total ammonia is defined as the sum of un-ionized ammonia (NH_3) and the ammonium ion (NH_4^-). Concentrations should be expressed in terms of

milligrams per litre of nitrogen and to an accuracy of 0.01 mg/l.

NITRITE PLUS NITRATE - Determine and record the concentration of total nitrite plus nitrate nitrogen at the same depths as for ammonia: 1 metre, 5 metres, 10 metres, 20 metres, 30 metres, and 1 metre above the bottom. Concentrations should be expressed in terms of milligrams per litre of nitrogen and to an accuracy of 0.01 mg/l.

4.5 CURRENT SPEED AND DIRECTION

All farms in Monitoring Schedule C must characterize the current regime at the farm site for a period of one month only. Current speed and direction are to be recorded at a minimum frequency of once per hour during the one month (30 days) period, so an automatic recording device is a necessity. These devices can be rented or purchased, but use of a qualified consultant is the simplest alternative and is recommended. In some cases, the current monitoring requirements may have already been met as a result of previous studies. If so, these data may be submitted subject to the approval of the Regional Waste Manager without further monitoring. Report data on Data Form III (Appendix 4). This monitoring requirement must be met within two years of a farm becoming subject to Schedule C.

The precise timing of the current assessment is left to the discretion of the farmer, but current measurements must be made during a month of average tidal fluctuations. Measurements of current speed and direction must be made at intervals of one hour or less until a full 30 days have elapsed.

The current measuring instrument should be located away from the attenuation effects of the netcages or other farm structures. In other words, it should not be located immediately adjacent to the netcages and not in line with prevailing currents such that the current meter is measuring currents that have been "dampened" by the nets themselves. In most cases, the current meter should

be moored about 30 metres from the offshore side of the netcages. The current meter should be suspended from a surface float at a depth of 15 metres. Record current direction in degrees true and current speed in cm/sec. Either vector averaging or instantaneous type meters may be used.

Upon completion, compiled data is to be forwarded to the Regional Waste Management office. Raw data indicating current speed and direction for each sampling interval should be provided in an ASKI computer format (diskette or mag tape) and must be accompanied by adequate format documentation. Submitters should also include a summary of the data in the form of a tabular frequency distribution of both current speed and current direction as specified on Data Form III. Refer to section 1.9 of the appendix for further details on methodology.

Data Form III has the following format:

START DATE - Record the date that the current meter commenced current monitoring.

START TIME - Record the time that the current meter commenced current monitoring. Use local time and a 24 hour clock.

END DATE - Record the date that current monitoring was terminated.

END TIME - Record the time that current monitoring was terminated. Use local time and a 24 hour clock.

SAMPLE INTERVAL - Report the sample interval in minutes between consecutive measurements made by the meter. Sample interval cannot be greater than sixty minutes.

INSTRUMENT - Provide details as to the make and model of current meter employed to conduct the monitoring.

DATA - Indicate whether current meter averages current speed and direction over the selected interval, or if it provides instantaneous measurements.

NAME - Provide the name of the person or consulting company that is performing the current monitoring.

4.6 SEDIMENT ACCUMULATION AND BENTHIC SURVEY

All Schedule C farms are required to conduct an annual underwater survey. This survey is to inspect the sea floor under the farm site to determine organic sediment accumulation and impact on the benthic community. The survey should be conducted during a period of good visibility in September or October. The exact timing of the survey is left to the discretion of the individual fish farm operator but it is important to sample after the main growing season and before the major winter storms. Once a survey date has been selected, subsequent annual surveys should be conducted on approximately the same date. Results of the survey must be compiled in a typed report and submitted to the Regional Waste Management office along with the other fourth quarter submissions. The initial underwater survey must be completed within two years of a farm becoming subject to Schedule C.

Diving will be necessary to make the required assessment, but in the interests of diver safety, the survey need not exceed a maximum depth of 30 metres. Diving around netcages can be hazardous and only qualified divers working in compliance with Workers' Compensation Board Regulations should be employed. Due to the specialized skills required to carry out this portion of the monitoring program, it is recommended that the diving be conducted or supervised by a qualified professional biologist to ensure that the assessment is reliable.

Farm operators may wish to employ a video equipped underwater "remotely operated vehicle" (ROV) as a possible alternative to the use of divers for some aspects of the survey. These devices can be rented or purchased, however their utility for such an application is not well established. Operators considering use of an ROV as part of their survey should consult with the Regional Waste Manager if deviations from the prescribed methodology are anticipated.

In order to comply with the survey requirements, the farm operator must establish two "transect lines" on the sea floor

beneath the netcages. A transect line is simply a measured line laid out in a straight line along the bottom. The transect line should be marked at each 10 metre interval along its length.

The transect lines are to be deployed in an array under the netcages according to the following description. Locate the first transect line (to be called Transect #1), by identifying the most central location under the netcage array. A transect line is to be deployed by a diver through this point and extending in a straight line or curve which parallels the depth contours under the pens. The transect should extend 30 metres beyond the outside perimeter of the overlying fish pens on each end of the transect.

The second transect line (to be called Transect #2) should be laid out at right angles to the first and should again pass through the already identified "central point." As before, the second transect line should extend 30 metres past the outer perimeter of the overlying fish pens on each end of the transect.

Due to diver safety concerns, the transect lines need not extend into depths greater than 30 metres. Transect #2 can be truncated if depths in excess of 30 metres are encountered. In circumstances where the pens are situated in an area exceeding 30 metres in depth (and consequently Transect #1 is in more than 30 metres of depth), the deployment of sediment traps may be used as an alternative to a diver survey. The sediment trap option is described in Section D following.

Once the two transect lines have been arranged as described, SCUBA divers are to establish reference marks at 10 metre intervals along the length of the transects. Metal rods such as common "re-bar" driven into the substrate are suitable for this purpose if the substrate is soft enough. In rocky areas, metal bars imbedded in concrete anchors should be used. In rocky areas of significant slope, the concrete anchors may not be suitable; in such circumstances the transect rope itself marked at 10 metre intervals will suffice.

Once the transect lines have been established and the reference marks are secured and calibrated for height, the survey can proceed to measurement of sediment accumulation. The transect lines and reference marks remain as permanent fixtures and need only be deployed during the initial survey. Subsequent annual surveys use the same transect/stake array. The only potential modifications that may be anticipated are extensions or re-orientation of the transects in the event of the expansion or relocation of the netcages on the farm. Transects must always extend 30 metres beyond outer perimeters of overlying netcages.

In some circumstances the dive supervisor may choose not to carry out the dive directly under the pens due to inadequate clearance between the bottom of the pens and the sea floor. In such a case, the transects would extend 30 metres beyond the perimeter of the netcage array in the same fashion as prescribed for the complete transects.

Results must be reported in the following format:

Section A - Site description

Provide a sketch map drawn to scale showing the following:

i. The entire farm site with netcages, walkways, buildings, etc.

ii. A directional arrow indicating "north."

iii. Show approximate areas of silt, sand, gravel, or rock substrate within the lease site.

iv. Indicate 10 metre (or less) depth contours for the farm site.

v. The map should show both transect lines and where they intersect at the most central point under the netcages. Transect lines should be labelled as Transect #1 or Transect #2 according to the convention described earlier.

vi. The 10 metre interval points where either a stake and/or a mark are located should be indicated on the diagram and

assigned consecutive numbers.

vii. A SCUBA diving team operating to a maximum depth of 30 metres must undertake an underwater reconnaissance of the farm site and determine to the best of their ability the extent of farm-derived sediment on the bottom. Farm-derived sediment is defined as uneaten fish feed, fish faeces, and organic accumulations from organisms fouling pens. The distribution of this sediment accumulation must be outlined on the sketch map as accurately as possible.

viii. Indicate the distribution of bacterial "mats" (i.e. Beggiatoa sp.), if present.

Section B - Sediment accumulations

Divers are to proceed along each transect line, and record the sediment thickness at each 10 metre reference mark. Measure from the top of the stake to the top of the sediment layer and subtract the initial overall height of the reference mark. This thickness should be recorded in centimetres. Divers must use extreme care in taking measurements in order to avoid disturbing the sediment layer. If the interval point has no stake (in steep, rocky areas), then a ruler or measuring stick is to be inserted in the sediment to the maximum possible depth, and the thickness of the sediment layer is to be recorded to the nearest centimetre.

DATE - Record the date that the survey was conducted.

TRANSECT - Indicate whether the transect is #1 or #2. Tfansect #1 parallels the depth contours, and Transect #2 is at right angles to Transect #1.

INTERVAL PCINT - Record the number of the interval point as was assigned on the sketch map. These numbers should be consecutive.

TYPE - Indicate whether the interval point is represented by a stake or is located on solid rock with no stake. Record

under TYPE as either "STAKE" or "NO STAKE".

DEPTH - Indicate the water depth in metres at each interval point. The diver's depth gauge is adequate for this measurement.

SEDIMENT - Record the sediment measurement for each interval point along the transects in centimetres as described earlier (i.e. height of exposed marker minus initial marker height or depth of sediment overlying rock). If the interval point is has no overlying sediment, record a zero.

Section C - Benthic fauna and flora survey

SCUBA divers are to proceed along each transect line and at each 10 metre marker, the five most dominant macrophytes and the five most dominant invertebrates within a 56 centimetre radius of the marker are to be identified (to genus or family) and recorded. Estimate the number of individuals of each group within the radius (equivalent to one square metre) and express in terms of individuals/m^2 or percent cover. Inconspicuous infauna need not be sampled or identified.

DATE - Record the date that the survey was conducted.

TRANSECT - Indicate whether the transect is #1 or #2.

INTERVAL POINT - Record the number of the interval point as was assigned on the sketch map. These numbers should be consecutive.

MACROPHYTES - List the five most dominant macrophytes in the square metre surrounding the transect marker.

MACROPHYTE DENSITY - Estimate the corresponding density of each of the five dominant macrophytes. Record as individuals/m^2 or percent cover.

INVERTEBRATES - List the five most dominant invertebrates in the square metre surrounding the transect marker.

INVERTEBRATE DENSITY - Estimate the corresponding density of each of the five dominant invertebrates. Record as

individuals/m^2 or percent cover.

SUMMARY - In addition to reporting results from the transect survey, a brief qualitative summary should be included to provide a characterization and comparison of the following three habitats:

i. The benthic community directly impacted by farm deposition.

ii. The benthic community adjacent to the deposition area within the lease site.

iii. A control area beyond the influence of the farm. Compare areas of similar substrate type, depth, and exposure to currents and wave action.

If any fish were encountered during the survey, their species and relative abundances should also be noted in the survey report.

Section D - Sediment traps.

This section is intended as a substitution only for those farm sites where a diver survey is not considered feasible because all or most of transect #1 would be located in more than 30 metres of water. The dive survey (Sections A-C) must be conducted if the 30 metre maximum is not exceeded. Sediment trap analysis requires deployment of six sediment traps for a one month period on an annual basis (design and methodology elaborated in section 1.12 of the appendix). Four of the traps should be located around the perimeter of the netcage array and one should be located in the approximate centre of the array. Precise location of the traps should be selected to ensure maximum expected accumulation rates due to dispersion by prevailing currents. The sixth trap should function as a control and should therefore be suspended at a depth comparable to the other traps but at a suitable location away from the immediate influence of farm sediments.

Sediment traps must be suspended five metres above the bottom for a collection period of one month duration each year. This

collection period should be selected to correspond to a period of average feed usage and average farm biomass. When the traps have been retrieved after their one month collection period, their contents must be analyzed for dry weight (105^{0}C) and recorded as grams/m^2/month.

SKETCH MAP - Provide a sketch map drawn to scale showing the following:

i. The entire farm site with netcages, walkways, buildings, etc.

ii. A directional arrow showing "north."

iii. Indicate location of each sediment trap and assign each trap an arbitrary number. If the "control" trap is not within the confines of the sketch map, provide a written description of its location.

DATE - Indicate the interval that the sediment traps were in the water. The interval should be approximately one month.

TRAP NUMBER - Record the trap number as assigned on the sketch map.

TRAP DEPTH - Indicate the depth in metres at which the trap was deployed.

DRY WEIGHT - Record the dry weight of the accumulated sediment from the trap. Dry weight should be expressed as grams/m^2/month.

Completion of Sections 4.1 through 4.6 fulfill all of the basic Schedule C monitoring requirements. Additional information may be required by the Regional Waste Manager in response to site specific environmental circumstances. The fish farm manager is encouraged to submit any further data or observations felt to be relevant to the interpretation of information supplied as part of the Environmental Monitoring Program (for example, details of the occurrence of fish kills due to specific diseases or plankton blooms).

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APPENDICES

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1. EQUIPMENT AND METHODS

1.1 INTRODUCTION

Equipment requirements, sampling methods and analytical methods for water, sediment, and feed testing are presented in detail in the following sections. These will assist the farmer or consultant in planning and implementing the program and will ensure consistency in results. For many of the water quality parameters required by the Environmental Monitoring Program, several techniques are presented. The individual fish farm operator may select the methodology that best utilizes existing equipment and provides practical, economical, as well as accurate sampling. For certain variables, specific methods are required. Amendments to these methods may be made with the approval of the Regional Waste Manager.

1.2 FEED MOISTURE CONTENT

Determination of moisture content of feed is a simple procedure which requires a drying oven, aluminum trays, and an analytical balance. Any oven capable of operating at 105^{0}C(plus or minus 5^{0}C) for extended periods will do. The balance used for weighing need only be sensitive to 0.1 gram, but should be capable of handling a maximum weight of at least 500 grams.

Select several replicates of the feed to be tested; the number of replicates depends on how well the feed is homogenized. Between three to ten replicates may be necessary. Ensure that the samples selected for analysis have a moisture content typical of the feed at the time of its actual use.

The analytical procedure is as follows:

i. Weigh an empty aluminum tray and record its weight to the closest 0.1 gram (Value A).

ii. Place approximately 300-400 grams of the "wet" feed sample on the tray, and again weigh and record (Value B).

iii. Dry the sample on the tray at 105°C (plus or minus 5°C) for ten hours.

iv. Weigh the tray and its dry contents and record to the closest 0.1 gram (Value C).

v. Calculate percent moisture as:

[(Value B - Value C) / (Value B - Value A)] x 100

1.3 IN SITU SAMPLING

Water sampling methodologies can be divided into two broad categories. The first of these is called in situ sampling whereby electronic probes or other specialized equipment (such as a Secchi disc) are used to directly measure water quality characteristics at specific sample locations. For example, an in situ salinity measurement would involve lowering an electronic salinity probe to a specific depth at a specific site location. A direct readout of salinity concentration is obtained for that particular location.

The other sampling methodology (to be discussed in the following Section 1.4) requires collection of an actual water sample from the specified depth and location. The water sample is retrieved to the surface for subsequent analysis using electronic, chemical, spectrophotometric or other techniques. Some of these analyses may be conducted in a laboratory.

The Environmental Monitoring Program requires in situ measurements for two parameters: Secchi depth and current speed/direction. Secchi depth is determined with a special yet simple device known as a Secchi disc. Current direction and speed are measured with a current meter. Both of these methods are described more fully in subsequent sections.

Current meters are specialized electronic meters that are moored in the water column to record speed and direction of the water currents. Other instruments also are available to provide in situ measurements of temperature, salinity, dissolved oxygen, and depth. Electronic meters are an attractive alternative for water sampling as they permit very rapid measurements and are

relatively simple to use. Unfortunately, good electronic meters are fairly sophisticated devices and consequently are expensive to purchase. A more serious problem, however, is the dependability of the meter. The electrical components are subject to breakage and corrosion in a typical marine application, and the sensitive electrodes of the probes are very easily damaged. Consequently, electronic meters must be constantly tested for accuracy, and routine calibrations are essential. These calibrations can be tiresome and must be performed to very rigorous (manufacturer's) specifications. Repairs to damaged equipment are often lengthy and costly.

Within these restrictions, however, electronic meters can still be considered very effective analytical tools. Probes for temperature, salinity, dissolved oxygen, current and depth can be obtained separately or in various combinations. For example, combined temperature/salinity probes are common, and some companies even manufacture probes that measure all five parameters plus more in a single instrument. Costs vary considerably and range from simple probes that just measure a single parameter costing several hundred dollars, to very sophisticated probes that measure multiple parameters at a cost of several thousand dollars. It is important to ensure that adequate cable is obtained such that the probe can be lowered to the sea bottom below the netcages.

There are many manufacturers (YSI, Beckman Instruments, Applied Microsystems, Hach, Hydrolab, Aanderaa, etc.) and many suppliers (Comeau Technique, Aquatrol, General Oceanics, Sargent-Welch, etc.) of electronic meters. Information on these meters is best obtained directly from the manufacturer or supplier. General inquiries should be directed to scientific supply companies or to aquaculture supply companies. In addition, some assistance may be obtained by contacting staff at the following offices:

Ministry of Environment,
Water Management Branch,
Resource Quality Section,
Victoria, B.C.
PH: 387-9505
OR
Ministry of Agriculture & Fisheries,
Aquaculture & Commercial Fisheries Branch,
Aquaculture Industry Development,
Victoria, B.C.
PH: 356-1614

All electronic meters should come complete with operational manuals which will specify use, maintenance, and calibration of the device. These instructions must be followed explicitly to ensure effective and accurate results. Note that all probes should be given a couple of minutes to equilibrate at any given depth before a reading is recorded.

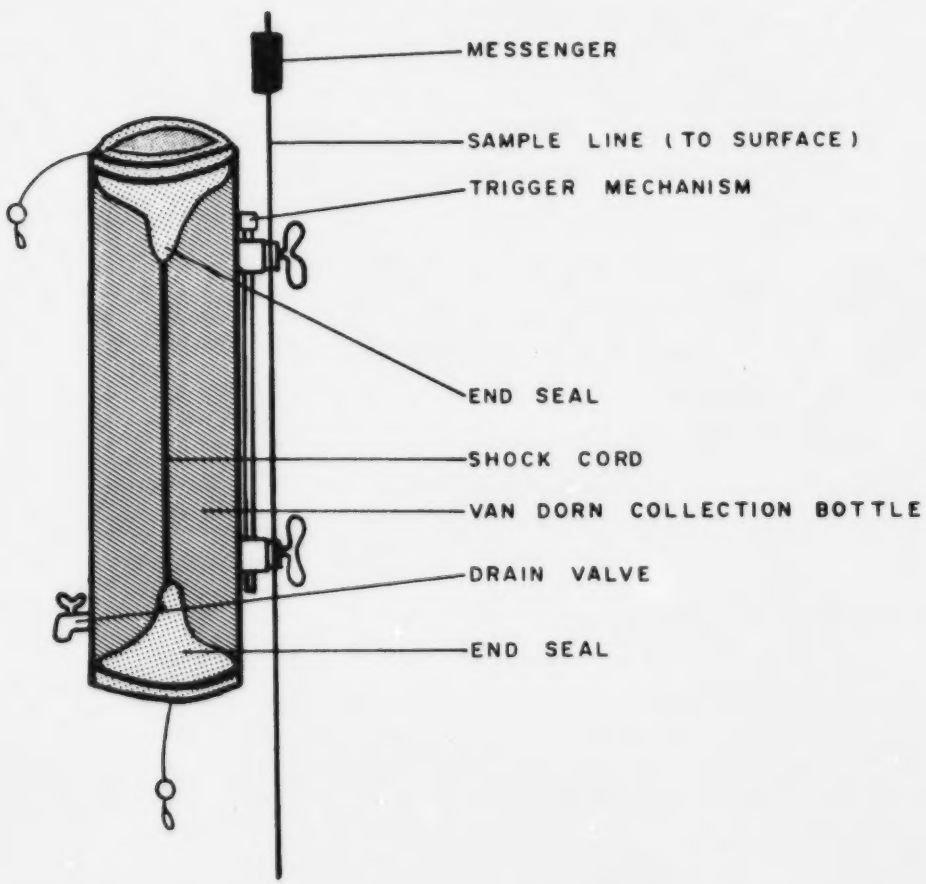
1.4 WATER SAMPLE COLLECTION

Collection of water samples for subsequent analysis on the surface is appropriate for measurements of the following: temperature, salinity, dissolved oxygen, ammonia, and nitrite plus nitrate. A variety of types of commercially manufactured water collection devices are available. Nisken bottles, Van Dorn bottles, alpha samplers, Kemmerer samplers, and Nansen bottles can all be used to collect water samples at any depths. Although these samplers differ from each other in some ways, all operate on the same principle. They consist of a collection vessel which is usually a cylindrical tube open at both ends. This tube is clamped to a weighted steel cable and is lowered to the depth at which a water sample is desired. When the desired depth is reached (as indicated by the measured steel cable), a dense weight called a "messenger" is attached to the cable at the surface. The messenger is released and allowed to slide down the cable and when it reaches

the collection vessel, it triggers the release of two seals which close off both ends of the tube. The tube, and the trapped water, is then retrieved to the surface where the water is removed for analysis.

Probably the simplest and most common type of water sampler is the "Van Dorn" type. In this type of sampler, the two end seals are held in place by a stretchy shock cord which runs through the centre of the vessel. The seals can be pulled back from the opening (against the pressure of the shock cord) and held open by attachment to the trigger mechanism. When a messenger is sent down the line and hits the trigger, the shock cord snaps the seals into place, trapping a water sample. This sort of device is diagrammed in Figure 1.

FIGURE I. VAN DORN BOTTLE



To lower and raise samplers, a winch is recommended. There are several options, however heavy duty downriggers used by sports fishermen such as the "Scotty Strongarm" and the "Penn 600" are readily available and are portable, allowing transfer from boat to wharf.

Van Dorn type samplers are available in a range of sizes. For the purposes of the Environmental Monitoring Program, a small sampler with a two litre capacity is adequate. Possible suppliers of such a sampler include the following:

i. Research Instrument Manufacturing Company Ltd.,
R.R. #2,
Guelph, Ontario. N1H 6H8
PH: (519) 822-1547

ii. Comeau Technique Ltd.,
(Agents for Cole-Parmer)
5708 Vanden Abeele,
St. Laurent, Quebec. H4S 1R9
PH: (514) 334-3165

iii. Wildco,
Wildlife Supply Company,
301 Cass Street,
Saginaw, Michigan. 48602
U.S.A.
PH: (517) 799-8100

Note that water sample collectors must be obtained in conjunction with a steel line of adequate length for farm depths, as well as one or more messengers.

Once a water sample has been collected, several alternatives are available for measurement of specific water quality parameters. In some cases, an electronic probe may be used. Other tests may be conducted through chemical or special analysis. These will be discussed in detail in subsequent sections.

A further alternative for some parameters is to draw off small water samples from the Van Dorn (or other) sampler into small sample bottles. These sample bottles can then be shipped to a commercial laboratory for analysis. There are several commercial laboratories in coastal B.C. capable of performing some or all of the analyses required by the Environmental Monitoring Program. The following is an incomplete list of some of these labs:

i. Can Test Ltd. Vancouver. 734-7276
ii. Seakem Oceanography Ltd. Sidney. 656-0881
iii. ABL Analytical Service Labs Ltd. Vancouver. 253-4188
iv. Chemex Labs Ltd. Vancouver. 984-0221
v. MB Research and Development Ltd. Victoria. 656-1334
vi. EVS Consultants Ltd. Vancouver. 986-4331
vii. Quanta Trace Labs Inc. Burnaby. 438-5226

Credible analytical laboratories should be prepared to undertake occasional quality assurance tests in cooperation with the Ministry of Environment.

1.5 SECCHI DEPTH

Secchi depth is simply a measure of water transparency. It is easily determined by lowering a standardized white disc (a Secchi disc) on a measured line to the depth at which it disappears from sight. Secchi discs can be purchased from many scientific supply houses, but this simple piece of equipment can be readily made by the fish farmer from common materials.

To construct a Secchi disc, cut a flat piece of approximately one quarter inch thick aluminum or plastic into a disc with a diameter of 25 centimetres. Drill a hole through the centre and insert an eyebolt or some other means of attachment to a rope. Weights should be added in such a way that the disc will maintain a horizontal orientation as it is lowered through the water. The upper surface of the Secchi disc should be divided into four equal

quarters. Alternate quarters are to be painted matte white and matte black. When a measured line is then attached to the eyebolt, the Secchi disk is ready to use.

To determine Secchi depth, select the shady side of the walkway (or shady side of the boat if this is your working platform) at your sample site. Lower the Secchi disc on its measured line to a point where it just disappears from sight. Note the depth (depth 1). Then raise the Secchi disc until it just comes into view. Note the depth again (depth 2). Halfway between these two depths is the Secchi depth (depth 1+2/2). The ability of the operator to see the disc varies greatly depending on surface reflection of the sky and smoothness of the water. Therefore, the disc should be viewed through a diving mask or a transparent-bottomed container to eliminate glare and reflections from the water surface. Record Secchi depth to the nearest 0.5 metre. If the Secchi disc goes all the way to the bottom without disappearing from view, then Secchi depth is simply recorded as "bottom".

1.6 TEMPERATURE

Electronic probes are available that can be lowered to the correct depth to obtain a temperature reading. Remember to let the probe equilibrate at each depth for a few moments before recording a reading.

An alternative method for measuring water temperature requires collection of a water sample from the desired depth. When the sample is brought to the surface, the upper seal of the Van Dorn (or similar) sampler can be opened and a thermometer inserted. It is important to obtain this measurement as rapidly as possible before the water sample changes water temperature to any significant extent. Water temperature should be recorded to the nearest 0.5 degrees Celsius.

1.7 SALINITY

Salinity is another water quality parameter that can be measured by means of a remote electronic probe. Again, it is important to let the probe equilibrate at each depth before obtaining a reading.

Alternately, a water sample can be collected at depth and retrieved to the surface for analysis. If this is the case, several techniques are available for determining the salinity of the sample.

A. The quickest way to measure salinity is to use an electronic meter (a salinometer or conductivity meter). If your meter does not have sufficient cable to reach required depths, or if it is a table-top model without cable, water samples can be retrieved from depth and measured at the surface. Simply remove the upper seal of the collection device, insert the salinity probe, and record the salinity after a few moments for equilibration. If the measurements are made with a conductivity meter, these values must be converted to salinity using a calibration curve constructed by employing the same meter on samples of a known salinity. Both types of meter require occasional calibration against standard solutions.

B. The hydrometric method can also be used to determine salinity. This technique relates specific gravity of a seawater sample (at a given temperature) to salinity by use of density salinity tables. A set of three seawater hydrometers and a thermometer are required in addition to the tables in order to use this method. Seawater hydrometers are specially calibrated and should be obtained from a scientific supplier (such as Kahl Scientific Instrument Corp., PO Box 1166, El Cajon, Calif. U.S.A. 92022). For the necessary density salinity tables as well as step-by-step procedures to be followed, please consult Standard Methods for the Examination of Water and Wastewater, 16th ed.

C. A refractometer is a small and simple to operate device that measures refractive indices and concentrations. It can also be used to determine salinities. This method does not provide the accuracy of some of the other methods, but is adequate for the purposes of the Environmental Monitoring Program (i.e. plus or minus 0.5 parts per thousand).
A hand-held refractometer is very easy to use. A drop or two of the sample water is extracted from the collection device and placed on the prism of the refractometer. This prism must be thoroughly cleaned prior to each use. A cover plate is then closed and the refractometer is held up to the light while the operator looks through the eyepiece. The device is focused and the operator then reads the salinity directly from the internal scale.

Refractometers are available from several scientific supply houses, but care is required in selecting a model appropriate for salinity measurements; i.e., it must cover a range suitable for saltwater and must allow a resolution to plus or minus 0.5 parts per thousand. Be sure the supplier is familiar with the intended use of the refractometer before you purchase one. A suitable refractometer is the "Goldberg" model. Note that a refractometer requires occasional calibration against standard solutions.

D. Chemical methods are also available for the determination of salinity. These are essentially laboratory techniques that require a number of reagents and some lab apparatus. If the fish farm has the facilities to attempt such a determination, please refer to the argentometric method as described in Standard Methods for the Examination of Water and Wastewater, 16th ed., or the titration method as outlined in A Practical Handbook of Seawater Analysis, (Strickland & Parsons,1972), or Chemical and Biological Methods of Water Analysis for Aquaculturalists, (Stirling,1985).

If chemical analysis is to be attempted, water samples should be drawn out of the Van Dorn (or other) sampler into a 240 millilitre glass bottle with a No. 6 cork. The glass bottle should be rinsed three times with the sample water before collecting a final sample. Fill the bottle to the shoulder with sample water and then seal with the cork, which should have been previously soaked in melted paraffin wax for 30-40 seconds. The waxed cork should be inserted a few millimetres below the level of the neck. Thus sealed, the sample remains stable (with respect to salinity) for up to two days. If storage for a longer period of time is required, dip the neck of the bottle in melted wax. The sample will then remain stable for an indefinite period.

E. Commercial analytical laboratories will provide salinity analysis if required. It is still necessary however, for the farm operator to collect the samples. Samples should be collected as described in the preceding paragraph and sealed with wax. Bottles should of course be accurately labelled with sample location, depth, and date.

1.8 DISSOLVED OXYGEN

Dissolved oxygen, or "D.O.". can be measured in situ with an electronic meter, if available. Make sure that the probe is fully submersible as some units are meant to have only the membrane portion of the probe submerged. Dissolved oxygen probes are very sensitive devices and the manufacturer's instructions should be read thoroughly and followed explicitly. The membrane electrodes should never be permitted to dry out and calibrations must be carried out frequently. Note that the probe should be placed in seawater for several minutes before use in order to equilibrate.

Dissolved oxygen meters can also be used to analyze samples retrieved to the surface. This can be done if there is insufficient cable to reach desired depths, if the meter is a table-top model, or if the probe is not fully submersible. As with

temperature and salinity, measurements should be commenced as soon as the water sample arrives at the surface. Dissolved oxygen levels change with temperature and exposure to the atmosphere, so it is important to obtain a reading quickly. Nevertheless, a few minutes must still be permitted for the probe to equilibrate. The probe should be inserted directly into the water sampler (i.e. Van Dorn); do not transfer water into another container. Although D.O. probes are the most convenient means of determining dissolved oxygen levels, water samples can also be analyzed chemically. Chemical analysis is normally performed through application of the Modified Winkler technique. This is a technique best carried out in a laboratory environment, as reagents and lab apparatus are required. It is also however, a very good technique which usually surpasses D.O. probes in both accuracy and precision. In fact, Winkler technique is the preferred method for calibrating oxygen probes and fish farmers are encouraged to learn and use this method. Should the farmer decide to utilize the Modified Winkler technique, refer to the iodometric test in Standard Methods for the Examination of Water and Wastewater, 16th ed., A Practical Handbook of Seawater Analysis, (Strickland & Parsons,1972), or Chemical and Biological Methods of Water Analysis for Aquaculturalists, (Stirling,1985).

Water samples withdrawn from the collection bottle for lab D.O. analysis must be treated with utmost care to avoid introduction of atmospheric oxygen into the sample. Sample water should be immediately drawn into 300 millilitre narrow-mouth glass bottles fitted with tapered, ground-glass stoppers (Winkler bottles). Water from the collection bottle should be introduced to the sample bottle via a rubber tube extending to the bottom of the sample bottle (i.e. do not allow sample water to splash into the sample bottles). Allow water to overflow the sample bottle until it has been flushed with approximately three times its own volume. Then insert the stopper such that no air bubbles are allowed into the bottle.

If Modified Winkler analysis is not to begin immediately (i.e. within 15 minutes), the samples can be temporarily stabilized by the addition of two reagents. Remove the stopper from the sample bottle, and using a pipette or syringe, introduce 0.5 millilitres of Winkler Reagent A per 100 millilitres of sample volume. Then add 0.5 millilitres of Winkler Reagent B per 100 millilitres of sample volume. Add the reagents below the surface level of the sample (i.e. do not allow it to drop into the samples). Replace the stopper taking care once again to exclude any air, and shake well. The sample bottle should then be stored away from strong light, and preferably submerged in water of the same temperature as when collected (or at 10-20°C). This permits storage of the sample for 48 hours before the sample analysis must be completed. It also affords the farm operator the opportunity to ship the stabilized samples to a commercial analytical laboratory to complete the analysis if so desired. The Winkler reagents required for stabilization can be prepared as follows:

Winkler Reagent A:

Manganous sulphate solution, 2.2 M:
(Dissolve 240 g of $MnSO_4 \cdot 4H_2O$ or 180 g of $MnSO_4 \cdot H_2O$ in water and dilute to 500 ml).

Winkler Reagent B:

Winkler's reagent (alkaline iodide solution):
(Dissolve 200 g of sodium hydroxide, NaOH, in 280 ml distilled water. Add 450 g of sodium iodide, NaI, cool and dilute to 500 ml).

A number of prepackaged D.O. "test kits" are also available on the market, but for the most part these do not provide sufficient accuracy for the purposes of the Environmental Monitoring Program. Dissolved oxygen must be determined to an accuracy of plus or minus 0.2 mg/l. Hach Company does manufacture a D.O. kit that meets this criteria. The kit uses a digital titrator and is of sufficient accuracy for this program.

1.9 CURRENT SPEED AND DIRECTION

Electronic current meters capable of determining both speed and direction are available from several manufacturers (Aanderaa, Applied Microsystems, General Oceanics, InterOcean Systems, etc.). Since the Environmental Monitoring Program requires that currents be measured at a minimum of one hour intervals for a period of one month, it is advisable to use a meter which can be pre-set for the correct interval, and record the results automatically (i.e. the meter should possess an internal "datalogger").

These devices are expensive and often require some expertise to program and deploy properly, in addition to extracting the data appropriately. It is therefore recommended that the services of a qualified consultant (who already has the necessary equipment and expertise) be retained to fulfill this monitoring requirement. The Buyers Guide of the Canadian Aquaculture Magazine provides a useful listing of many of the environmental consultants in British Columbia.

1.10 AMMONIA NITROGEN

Ammonia nitrogen cannot be measured in situ, so water samples must be collected for this analysis. Ammonia probes do exist, but they do not show good resolution at the low ammonia levels typical of seawater. Similarly, a number of ammonia "test kits" are available on the market but they also show poor resolution and are not satisfactory for the purposes of the Environmental Monitoring Program.

Laboratory facilities are required for the determination of ammonia concentration. The recommended method to be used is the phenol-hypochlorite procedure as outlined in A Practical Handbook of Seawater Analysis, (Strickland & Parsons,1972), Standard Methods for the Examination of Water and Wastewater, 16th ed., or Chemical and Biological Methods of Water Analysis for Aquaculturalists, (Stirling, 1985). Since these procedures involve the use of specialized laboratory equipment including a spectrophotometer, it

is suggested that the samples be forwarded to an analytical laboratory for processing.

Water samples should be drawn from the sampler (Van Dorn or other) into clean 250 millilitre plastic sample bottles. Sample bottles should be rinsed twice before filling for a final time. Leave sufficient air space at the top of the bottle to allow for expansion during freezing. Make sure that the sample bottles are appropriately labelled with location, depth, and date. As soon as possible, place the sample bottles in a freezer until they are frozen solid. Samples will remain relatively stable in this condition for several days.

When all samples from a particular sample date have been collected and frozen, forward them in insulated, iced containers by the swiftest means available to a commercial laboratory. The samples should arrive at the lab at least partly frozen, so regular postal service should not be relied upon. Couriers or bus lines normally offer same-day or overnight delivery and are recommended for shipment of samples if personal delivery is not possible.

1.11 NITRITE+NITRATE NITROGEN

As was the case for ammonia analysis, nitrite+nitrate concentration determinations are restricted to lab analysis. The standard references given above should be consulted for specific analytical procedures. The cadmium reduction method should be used. No additional sample bottles are required for nitrite+nitrate samples, as the previously collected ammonia sample bottles contain adequate amounts of water to also complete this analysis. Again, it is important to ensure that the samples are frozen and then shipped to a lab as fast as possible (i.e. no more than one week after collection).

1.12 SEDIMENT TRAPS

The sediment collection canisters (traps) which are required for the Environmental Monitoring Program are based on a design

modified from a chamber developed by the Institute of Ocean Sciences (IOS) for open ocean sediment collection. Figure 2 (page 70) provides a schematic representation of the canister modified for benthic work in this study. Canister designs significantly different from the recommended design may be used subject to the approval of the Regional Waste Manager.

The cylindrical canister, constructed of 5 mm thick PVC sewer pipe, stands approximately 50 cm high with an inner (capture) diameter of 14 cm. The bottom collection "cup" is made of transparent plexiglass which can be removed from the canister assembly upon retrieval. Both the collection cup and the top 8 cm of the canister assembly are equipped with baffles (1.0 cm square openings) designed to minimize cross-current turbulence which may otherwise disrupt material entering the sediment collection canister. The baffle can be constructed using acrylic "eggcrate lighting panels".

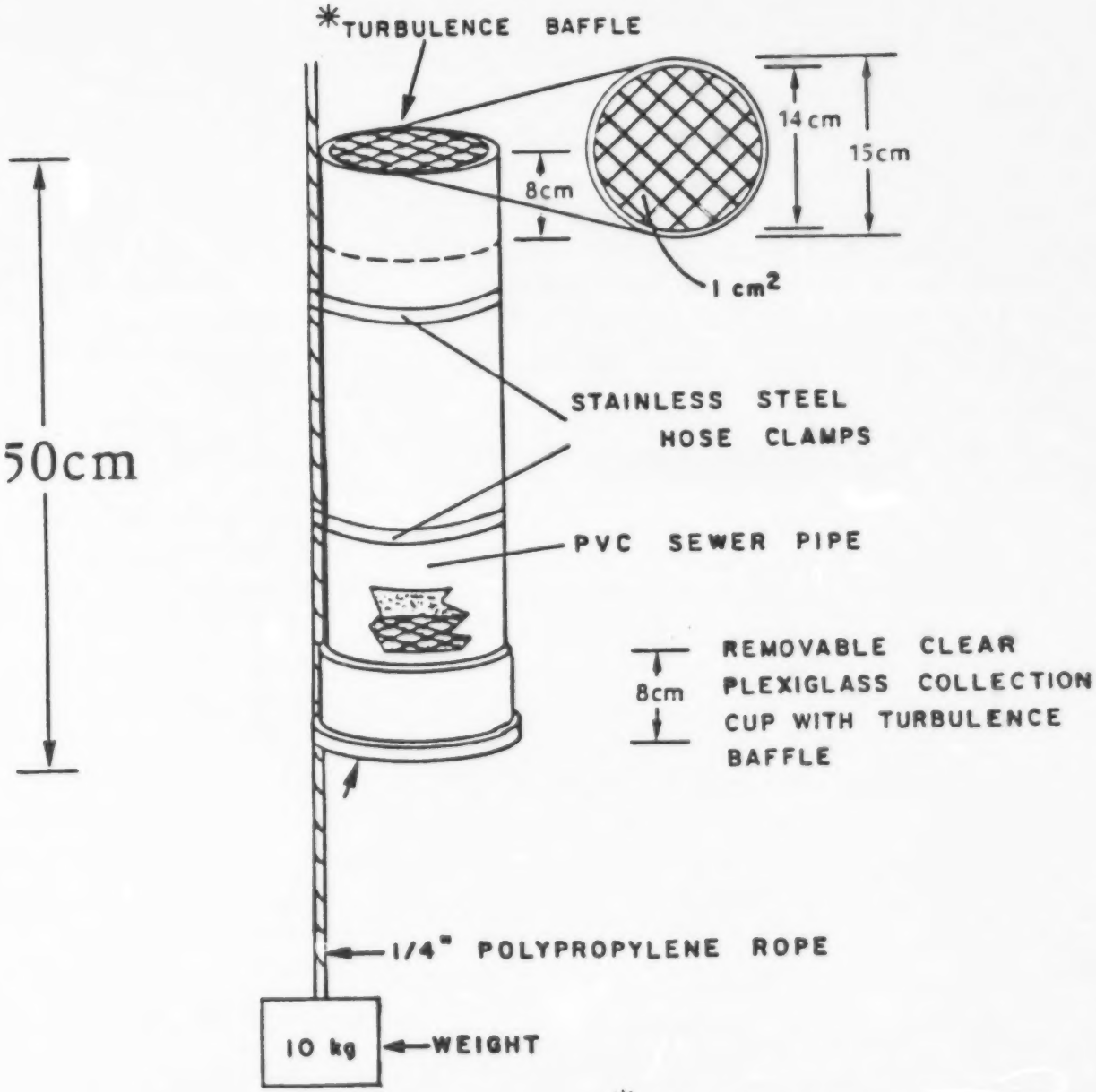
Siphon approximately 500 ml of concentrated, buffered formalin (100%) into the bottom collection cup, then fill the entire chamber with seawater. Material falling into the collection canister, including scavenging or net-fouling organisms which could consume an indeterminate proportion of the organic material accumulated over the sampling period, are thus immediately fixed.

Deploy the canisters from convenient locations along the netcage walkways. Slowly and carefully lower canisters to a position five metres above the sea floor at a mean tide and secure the retrieval line to the walkway. The retrieval line should be adequately weighted to ensure that the sediment trap is not subject to movement due to water currents.

After a one month deployment, the sediment traps should be slowly and carefully retrieved to the surface. Remove excess water down to the level of the lower baffle by syphoning. Ensure that the accumulated sediment has not exceeded the capacity of the collection cup. Should this have occurred, discard the sample and redeploy the canister for a shorter period of time. Remove the

FIGURE 2.

SEDIMENT COLLECTION CANISTER



collection cup and place the entire contents into a tared metal weighing tray. Wash any sediment residue from baffles and the collection cup into the weighing tray. Dry the entire contents of the weighing tray at 105°C to a constant weight. This usually takes 10-48 hours using a convective or forced draft oven. Weigh the residue to the nearest milligram and express the results in terms of $mg/m^2/month$.

Since the sediment analysis involves the use of an analytical scale as well as a laboratory oven, it may be advisable to retain the services of a consultant or a commercial laboratory for the analysis of the sediment samples. The extracted sediment samples can be shipped in any watertight container of suitable size. Method and timing of shipping are not critical for this analysis.

2. REFERENCES CITED

Anon., 1988. Canadian Tide and Current Tables. Canadian Hydrographic Service, Department of Fisheries and Oceans, Ottawa.

Anon., 1988. Environmental Guidelines For Marine Fish Farms and Ancillary Operations. Ministry of Environment, Victoria, B.C.

Caine, G., J. Truscott, S. Reid & K. Ricker, 1987. Biophysical Criteria for Siting Salmon Farms in British Columbia. Aquaculture Association of B.C. and Aquaculture and Commercial Fisheries Branch, Ministry of Agriculture and Fisheries, Victoria, B.C.

Chettleburgh, P. (ed.), 1987. Canadian Aquaculture Magazine--Buyers Guide. Vol. 3, No. 4., Harrison House Publishers, Victoria.

Greenberg, A., R. Trussel, & L. Clesceri (eds.), 1985. Standard Methods for the Examination of Water and Wastewater, 16th ed. American Public Health Association, Washington, D.C.

Stirling, H.P. (ed.), 19[illegible] Chemical and Biological Methods of Water Analysis for Aqualculturalists. Institute of Aquaculture, University of Stirling, Stirling.

Strickland, J. & T. Parsons, 1972. A Practical Handbook of Seawater Analysis. (2nd edition). Fisheries Research Board of Canada, Bulletin 167, Ottawa.

3. REGIONAL MINISTRY OF ENVIRONMENT WASTE MANAGEMENT OFFICES

3.1 For fish farms located on Vancouver Island or on the mainland coast between Toba Inlet and Cape Caution, contact:

Regional Waste Manager,
Waste Management Branch,
2569 Kenworth Road,
Nanaimo, B.C.
V9T 4P7

Phone: 758-3951

3.2 For fish farms located on the lower mainland from Vancouver to Toba Inlet and including the northern Gulf Islands (i.e. Texada Island), contact:

Regional Waste Manager,
Waste Management Branch,
15326 - 103A Avenue,
Surrey, B.C.
V3R 7A2

Phone: 584-8822

3.3 For fish farms located on the central mainland coast from Cape Caution to Milbanke Sound, contact:

Regional Waste Manager,
Waste Management Branch,
1259 Dalhousie Drive,
Kamloops, B.C.
V2C 5Z5

Phone: 374-9717

3.4 For fish farms located on the Queen Charlotte Islands or on the northern mainland coast north of Milbanke Sound, contact:

Regional Waste Manager,
Waste Management Branch,
1011 - 4th Avenue,
Prince George, B.C.
V2L 3H9

Phone: 565-6155

4. DATA ENTRY FORMS

4.0 The attached sample data forms must be used for all information requirements except the Schedule B and Schedule C sediment accumulation and benthic survey results. Additional data forms can be obtained from Regional Waste Management offices as required. The sediment accumulation and benthic survey results should be presented as reports and must be typed.

DATA FORM I

MATERIALS ACCOUNTING, FISH PRODUCTION, AND WASTE HANDLING

A. GENERAL INFORMATION

Key Number _____

Quarter _____ Company Name _____

Year _____ Lands File Number _____

Site Location _____

_____

Latitude _____

Longitude _____ Net Depth: Deepest _____ Average _____

Name _____

Chart Datum _____ Telephone Number _____

Plankton Watch: YES ☐ NO ☐ Waste Permit Numbers _____

B. FEED TYPE AND QUANTITY

Type	Amount	% Moisture	Dry Weight

Total Dry Weight= _____

C. Other Materials

Name	Type	Amount	Application

D. **PRODUCTION**

Biomass _____ kg
Weight Of Mortalities _____ kg

E. **DEAD FISH DISPOSAL**

☐ Landfill by farm operator
☐ Off Site Disposal
☐ On Site Rendering
☐ Off Site Rendering
Specify location/method/contractor _____
_____
☐ Other Specify _____

F. **SEWAGE DISPOSAL**

Average number of people on site = _____

☐ Chemical Toilet
☐ Compost Toilet
☐ Incinerator Toilet
☐ Septic Tank
☐ Other, Specify:
_____

If using a Septic Tank:
☐ Land Disposal To Tile Field Near Site
☐ Marine Discharge, Specify Depth Of Discharge _____
Specify tank volume _____

G. **BLEEDING**

On Site Bleeding: No ☐
Yes ☐

If Yes, specify effluent disposal method:
_____
_____

H. **PROJECTED ANNUAL FEED USAGE**

(to be completed for third quarter report only)

Type	Amount	% Moisture	Dry Weight

Projected Annual Feed Total = _____
Projected Monitoring Schedule = ___

I HEREBY CERTIFY that the information given in this quarterly submission is correct to the best of my ability.

Consultant Name if applicable _____
Signature _____ Date _____ 19__

DATA FORM II

MONTHLY TEMPERATURE (°C) AND SALINITY (‰) PROFILES FOR ONE YEAR

DATE												
TIME												
DEPTH												
TIDE STATUS												
	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.
Sample Depth												
1												
5												
10												
20												
30												
Bottom -1												

DATE												
TIME												
DEPTH												
TIDE STATUS												
	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.	Temp.	Sal.
Sample Depth												
1												
5												
10												
20												
30												
Bottom -1												

DATA FORM III

CURRENT SPEED AND DIRECTION

Start Date: _____ End Date: _____
Start Time: _____ End Time: _____

Length of Sampling Interval: _____

Instrument Make: _____
Model: _____

Data Averaged Over Interval ☐
Data Instantaneous ☐ Check One

Name of person/consultant deploying meter: _____
_____

Submit raw data specifying interval, current speed (cm/sec.) and current direction (degrees true). If computer diskette or magnetic tape is submitted, please provide format documentation. Summarize results in the frequency table below. Find the appropriate row and column and enter the number of observations. Put the total number of Direction/Speed Pairs in the small box at the bottom of the frequency table.

SPEED (CM/SEC.)

DIRECTION (DEG. TRUE)	0 to 2	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	20 to 22	22 to 24	24 to 26	26 to 28	28 to 30
0 to 20															
21 to 40															
41 to 60															
61 to 80															
81 to 100															
101 to 120															
121 to 140															
141 to 160															
161 to 180															
181 to 200															
201 to 220															
221 to 240															
241 to 260															
261 to 280															
281 to 300															
301 to 320															
321 to 340															
341 to 360															

☐

(Total Number of Direction/Speed Pairs)

DATA FORM IV

MONTHLY TEMPERATURE (°C) AND DISSOLVED OXYGEN (mg/l) PROFILES (April - Sept.)

APRIL

	UPSTREAM		DOWNSTREAM	
DATE			same	
TIME				
TIDE STATUS			same	
DEPTH				
SECCHI DEPTH				
Sample Depth	Temp.	D.O.	Temp.	D.O.
1				
5				
10				
20				
30				
Bottom -1				

MAY

	UPSTREAM		DOWNSTREAM	
			same	
			same	
	Temp.	D.O.	Temp.	D.O.

JUNE

	UPSTREAM		DOWNSTREAM	
DATE			same	
TIME				
TIDE STATUS			same	
DEPTH				
SECCHI DEPTH				
Sample Depth	Temp.	D.O.	Temp.	D.O.
1				
5				
10				
20				
30				
Bottom -1				

JULY

	UPSTREAM		DOWNSTREAM	
			same	
			same	
	Temp.	D.O.	Temp.	D.O.

AUGUST

	UPSTREAM		DOWNSTREAM	
DATE			same	
TIME				
TIDE STATUS			same	
DEPTH				
SECCHI DEPTH				
Sample Depth	Temp.	D.O.	Temp.	D.O.
1				
5				
10				
20				
30				
Bottom -1				

SEPTEMBER

	UPSTREAM		DOWNSTREAM	
			same	
			same	
	Temp.	D.O.	Temp.	D.O.

DATA FORM V

MONTHLY TEMPERATURE (°C), SALINITY (‰) AND DISSOLVED OXYGEN (mg/l) PROFILES

Quarter:_____

UPSTREAM

	AM			PM
DATE				same
TIME				
TIDE STATUS				
DEPTH				
SECCHI DEPTH				
Sample Depth	Temp.	Sal.	D.O.	D.O.
1				
5				
10				
20				
30				
Bottom -1				

DOWNSTREAM

	AM			PM
				same
	Temp.	Sal.	D.O.	D.O.

UPSTREAM

	AM			PM
DATE				same
TIME				
TIDE STATUS				
DEPTH				
SECCHI DEPTH				
Sample Depth	Temp.	Sal.	D.O.	D.O.
1				
5				
10				
20				
30				
Bottom -1				

DOWNSTREAM

	AM			PM
				same
	Temp.	Sal.	D.O.	D.O.

UPSTREAM

	AM			PM
DATE				same
TIME				
TIDE STATUS				
DEPTH				
SECCHI DEPTH				
Sample Depth	Temp.	Sal.	D.O.	D.O.
1				
5				
10				
20				
30				
Bottom -1				

DOWNSTREAM

	AM			PM
				same
	Temp.	Sal.	D.O.	D.O.

DATA FORM VI

MONTHLY AMMONIA (mg/l-N) AND NITRITE PLUS NITRATE (mg/l-N) PROFILES (during slack water)

Quarter:_____

DATE TIME DEPTH		
	Ammonia	NO_2 + NO_3
Sample Depth		
1		
5		
10		
20		
30		
Bottom -1		

DATE TIME DEPTH		
	Ammonia	NO_2 + NO_3
Sample Depth		
1		
5		
10		
20		
30		
Bottom -1		

DATE TIME DEPTH		
	Ammonia	NO_2 + NO_3
Sample Depth		
1		
5		
10		
20		
30		
Bottom -1		

B.C. Reg. 470/88 Deposited December 2, 1988
O.C. 2164/88

Waste Management Act

AQUACULTURE WASTE CONTROL REGULATION

Interpretation

1. In this regulation

"dry weight" means the gravimetric determination of the total residue left in a vessel after drying to a constant weight at a temperature of 103° to 105° C;

"mortalities" means finfish that have died from disease, plankton bloom, stress or other similar causes and that are not marketed for human consumption;

"finfish netcage aquaculture operation" means a finfish netcage aquaculture operation located in tidal salt water at a site that is leased or licensed under section 35 or 36 of the *Land Act*;

"operator" means a person who owns a finfish netcage aquaculture operation and includes a person authorized by the owner to act as the operator.

Exemptions

2. A person who carries out a class of operation, activity, industry or work referred to in section 3 is exempt from the requirement to hold a permit or approval under the *Waste Management Act* in respect of the class if he meets the conditions and circumstances set out in section 3 in respect of the class and if he provides to the Regional Waste Manager, on his request, information that allows him to determine the existence and extent of the discharge of waste.

Classes

3. The classes of operations, activities, industries or works referred to in section 2 are:

(a) the introduction of finfish feed or finfish fæces to tidal salt water from a finfish netcage aquaculture operation where

(i) the total feed usage does not exceed 630 tonnes dry weight per year,

(ii) the use, storage and disposal of materials and wastes on or off the finfish netcage aquaculture site is carried out in a manner that minimizes odour, risk of spillage and attraction of and impact on wildlife,

(iii) the operator complies with a monitoring program, stipulated by the manager, that allows the manager to determine

(A) the existence and extent of environmental impact caused by the operation,

(B) whether finfish aquaculture is likely to result in any alteration, disruption or destruction of wildlife, finfish, shellfish or their habitat,

(C) whether discharges of sewage are disposed of in a manner that causes pollution, and

(D) whether therapeutants, anesthetics, disinfectants, pesticides, wood preservatives, antifouling agents and other similar materials are stored and applied in a manner that causes pollution,

(iv) the operator complies with any requests by the manager for information in addition to the monitoring program under subparagraph (iii) for the purpose of allowing the manager to determine the matters set out in subparagraph (iii) (A) to (D),

(v) the operator notifies the manager regarding changes to the aquaculture operation that may affect the kind or quantity of the wastes disposed of or discharged,

(vi) pollution is caused by the aquaculture operation, and the operator, as soon as possible in the circumstances, reports the pollution to the manager and takes appropriate action, as directed by the manager, to ameliorate the pollution and prevent its recurrence, and

(vii) the operator prepares a contingency plan which documents procedures to be followed during a major fish kill, including the method of disposal of mortalities, and obtains the manager's approval to the plan;

(b) the introduction from a finfish netcage operation to tidal salt water of treated domestic sewage that is

(i) produced in a quantity that is less than 2.5 m^3 per day,

(ii) produced from premises located on the foreshore adjacent to tidal saltwater, or on tidal saltwater,

(iii) collected and treated in a septic tank that provides at least 2 days retention time for the sewage,

(iv) discharged at a depth greater than 15 m below hydrographic chart datum within the boundaries of the operation, and

(v) located more than 125 m from commercial or recreational shellfish resources.

Offence and penalty

4. (1) Every person who

(a) makes, participates in, assents to or acquiesces in the making of false or deceptive statements in a return, record or answer filed or made as required by or under this regulation,

(b) omits, or assents to or acquiesces in the omission of, entries in records required by or under this regulation, or

(c) in any manner evades or attempts to evade compliance with this regulation

commits an offence and, in addition to any penalty otherwise provided, is liable on summary conviction to a penalty not exceeding $2 000.

(2) No person commits an offence under subsection (1) (a) or (b) if he did not know that the statement or entry was false or deceptive and, in the exercise of reasonable diligence, could not have known that the statement or entry was false or deceptive.

[Provisions of the *Waste Management Act* relevant to the enactment of this regulation: section 35]

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